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INTERPRETATION OF DAIRY PEDIGREES.

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BULLETIN 318

INTERPRETATION OF DAIRY PEDIGREES.[1]

By John W. Gowen.

Registers of Ancestry.

Since evolution by the introduction of written records, called mankind out of the morass of oblivion, there has grown up in the livestock industry methods of recording an animal and its parents. Started as private enterprises, often based on the records of one herd, these records have extended to many published volumes. In fact in the United States the herd register has almost become a public utility. This utility is based on the breed, each breed maintaining its own herd register or stud book as the case may be. Four great classes of agricultural animals are included in these registers, horses, cattle, sheep and hogs. The registering of poultry and other economic animals is far less important.

The systems used in herd registers are quite diverse. Those used for the recording of dairy cattle appear to be adequate and quite satisfactory when used in pedigree tracing. In their barest outlines they consist of recording the name and number of the offspring and the name and number of the sire and dam. Males and females are recorded separately. Each animal is given a distinctive name and number. All records are arranged numerically. They are not satisfactory for tracing the progeny of any given animal. The system as a whole is, however, so much better than that devised by man for recording his own ancestry that there is little room for complaint.

As practiced today the basis of registration of an animal lies in establishing the following points. First that the sire and dam

[1]Papers from the Biological Laboratory of the Maine Agricultural Experiment Station. No. 163. The Rockefeller Institute for Medical Research has contributed, in the form of a grant, much to the solution of the problems on which this paper is based. This paper is largely a reprint of a paper presented at the semi-centennial celebration Ontario Agricultural College.

of the animal were properly registered in the breed; second that the dates of service and birth are mutually compatible with the known facts about gestation and the sire and dam; and third that the characteristics of the animal (coat color etc.) are those of the breed. The details of the individual blanks vary with the requirements of the different breed offices.

WHAT IS A PEDIGREE?

A pedigree properly built up is a record of ancestry, of possible or probable prepotency, of inbreeding and relationships. It will nowadays show records of performance and frequently records of type. It gives a picture of the lines of descent and shows the famous ancestors to which the individual traces. The pedigree of the Holstein-Friesian bull, Baron Netherland DeKol, 28373 is shown below.

PEDIGREE OF BARON NETHERLAND DEKOL

Sheet No. / Sex ♂				
No. 28373 Baron Netherland DeKol	♂ No. 22187 Lord Netherland DeKol	No. 17713 ♂ Netherland DeKol's Perfection	No. 10625 ♂ Pietertje 2d's Koningin	No. 3515 Koningin van Friesland 5th's Netherland ♂
				No. 3273 HHB ♀ Pietertje 2d
			No. 10605 ♀ Netherland DeKol	No. 4584 HHB ♂ Netherland Alban
				No. 734 ♀ DeKol 2d
		No. 33688 ♀ Susie DeKol	No. 11584 ♂ DeKol 2d's Netherland	No. 4584 HHB ♂ Netherland Alban ●
				No. 734 ♀ DeKol 2d ●
			No. 20201 ♀ Daisy DeKol	No. 2767 ♂ DeKol 2d's Prince
				No. 2422 ♀ Belle Barnum
	♀ No. 44906 Susie DeKol's Countess	No. 21171 ♂ Count Mechthilde DeKol	No. 19056 ♂ Sir Abbekerk	No. 16469 ♂ Tirania's Sir Mechthilde
				No. 12702 ♀ Alberta Abbekerk 2d
			No. 10605 ♀ Netherland DeKol ●	No. 4584 HHB ♂ Netherland Alban ⊕
				No. 734 ♀ DeKol 2d ⊕
		No. 33688 ♀ Susie DeKol ●	No. 11584 ♂ DeKol 2d's Netherland ⊕	No. 4584 HHB ♂ Netherland Alban ⊕
				No. 734 ♀ DeKol 2d ⊕
			No. 20201 ♀ Daisy DeKol ⊕	No. 2767 ♂ DeKol 2d's Prince ⊕
				No. 2422 ♀ Belle Barnum ⊕

The pedigree of Baron Netherland DeKol as given above is of four generations showing the ancestry only, the records for production, type and show winnings not appearing. This pedigree could be extended much further, of course. The making of such a pedigree is quite simple. The number 28373 is looked up in the Holstein-Friesian herd book under bulls. The name is checked as Baron Netherland DeKol. The record then shows Baron Netherland DeKol's sire as Lord Netherland DeKol 22187 and his dam as Susie DeKol's Countess 44906. The sire, 22187, is next looked up under bulls and the dam, 44906, under cows obtaining the grandparents. The repetition of this process completes the pedigree. The pedigree is not extended beyond four generations because such a length of pedigree gives us most of the important points which may be utilized in determining what may be expected of the animal.

WHAT DOES THIS PEDIGREE SHOW US?

It is to be noted first that the granddam on the paternal and maternal side is the same animal, Susie DeKol 33688. In the third generation we find Netherland DeKol 10605 appearing in the sire's side and in the dam's side of the pedigree. In the fourth generation we find Netherland Alban 4584 HHB and DeKol 2d 734 appearing twice on the sire's side of the pedigree. The second appearance of these animals is noted by the solid circles in the space containing their names. The open circles with the cross indicates that the animals are repeated due to the repetition of those noted in the sentence just above.

Baron Netherland DeKol is consequently quite highly inbred, the inbreeding partaking of the nature of relationship between the sire and dam. In the sire's side of the pedigree we find that the sire himself is inbred, the animals Netherland Alban and DeKol 2d being repeated in his pedigree. In terms of inbreeding we find that Baron Netherland DeKol is inbred to 25% in the second generation, 37½% in the third generation and 50% in the fourth generation. If we calculate the total amount of inbreeding we find that for these four generations there is over 50% as much inbreeding as that found for brother and sister matings (1). Baron Netherland DeKol further displays the fact that his parents were related. On a percentage basis this relationship equals 50% in the second generation, 75% in the third generation and 75% in the fourth generation. From the standpoint of pedigree study these facts indicate that we are dealing with a highly inbred bull whose parents are also closely related. The question which must now be taken up is the influence of inbreeding or relationship on the milk yield and butterfat percentage of the progeny of such animals.

EFFECT OF INBREEDING ON MILK YIELD AND BUTTER-FAT PERCENTAGE.

Pedigree study then gives us the amount of inbreeding which has taken place in the ancestry of any animal. The point which we wish to know is the effect of this inbreeding on milk yield and butter-fat percentage. In the studies of this laboratory on the Jersey and Holstein-Friesian breeds it has been found that the inbreeding of all cattle in these breeds is relatively small in amount, taking them as an average (2, 3, 4). It has further been found that this small amount of inbreeding has no appreciable effect on milk yield and butter-fat percentage, the group of highest producing cows in the breed showing practically the same amount of inbreeding as does the lowest producing group. Not only that but the rate of inbreeding in the different groups is the same. The high producing cow is as likely to be highly inbred as the low producing cow. The conclusion may consequently be drawn that the study of the pedigree for inbreeding is likely to give little indication as to the actual milking qualities of the cow.

There is one other point to be taken into consideration in purchasing an animal for breeding purposes which need not be taken into consideration in purchasing an animal for its productive ability. Most inbreeding experiments show that the inbreeding of an animal is an indication of that animal's probable prepotency. If the inbreeding is large in amount that animal will probably reproduce its characters in its offsprings to a higher degree than will the animal whose inbreeding is of lesser amount. Probably the most noted illustration of this point is that furnished by the Bates Dutchess cattle. Wright (5) has recently analyzed the inbreeding and relationship which existed in these cattle showing that the inbreeding was quite high in amount and that the resulting prepotency of these animals would consequently be likely to be large in amount as their inbreeding would be expected to concentrate desirable inheritance in this strain. The historically notable results attained by the use of these Dutchess cattle indicate that in actual breeding practice this strain of cattle were preeminently prepotent when outcrossed, as would be expected from the results of a study of the inbreeding in this family.

Other results also tend to accompany inbreeding unless the breeder is very skillful in his selection to avoid them. The most important of these is reduced fertility in the individual which is highly inbred. A reduction in vigor is also often one of the accompanying effects of inbreeding. This result does not hold the same importance to the reduction in fertility, since it is possible, by the external appearance of the animal, to determine any reduction in vigor which may have taken place through inbreeding, whereas it is not possible to determine the reduction in fertility by the external appearance. All these detrimental results may be avoided by careful selection, however.

FAMOUS ANIMALS FOUND IN A PEDIGREE.

Famous animals obtain their prominence in a variety of ways. These methods include: advertising, records of merit, either in milk yield or butter-fat percentage, type as shown by show-ring winning, and nowadays by the number of times that animals are found in the pedigrees of cows whose production in milk yield or butter-fat percentage is phenomenal.

If we turn back to the pedigree of Baron Netherland DeKol it will be noted that it is possible to determine from such a pedigree, the animals whose progeny or owners have made them famous and consequently have enhanced the value of the animal whose pedigree is being studied. The greater the number of generations through which a pedigree is traced, the greater the possibilities of finding these famous ancestors. This is because of the fact that the chances of finding any important animals are increased considerably by the widening number of ancestors for each generation traced and by the relative decrease in number of possible ancestors due to the small number of importations of cattle into this country. Thus in the four generation pedigree of Baron Netherland DeKol we note Netherland DeKol in the third generation,—a cow which appears very frequently in the Holstein-Friesian pedigrees; DeKol 2d's Netherland,—a sire that is found in many pedigrees; DeKol 2d,—a cow that appears more frequently than any other animal in a four generation pedigree. The list of famous animals found in the pedigree of Baron Netherland DeKol could be much extended.

The illustration has made the problem evident, however. What is the significance of these animals to the probable milk yield of the cow which is pedigreed? Stated otherwise the question becomes, is an animal whose pedigree shows a large number of famous ancestors more valuable or more likely to produce a large quantity of milk or butter-fat than an animal whose pedigree does not contain so many of these famous ancestors. The results of extended studies on the Jersey and Holstein-Friesian breeds (2, 3, 4) have shown that the pedigrees of high producing animals or low producing animals or pedigrees of a random sample of the breed all contain animals which have been famous in the breed's development. In other words the mere presence in a pedigree of such a famous animal is no guarantee of the worth of the animal pedigreed.

The question of the frequency of the appearance of these famous animals in the pedigree has also been studied. In general it was found that animals which had Advanced Registry records have slightly more of these famous ancestors than the animals which did not have these Advanced Registry records. No difference in the average amount of milk produced by the Advanced Registry cows could, however, be noticed as the number of famous ancestors found in the pedigree was varied. These results seem to indicate that the presence of famous animals within a pedigree is but little indication of the possible productive worth of the animal so pedigreed. This conclusion may seem rather strange until it is realized that generally the famous animals are in point of fact quite distantly removed in number of generations from the animals whose milk production is to be determined. Thus while the famous ancestors undoubtedly in the majority of cases obtained their fame by their productive worth, they are so far removed from the animal which is pedigreed that their influence or chance of transmitting to it desirable characters for milk yield and butter-fat percentage is very small. This deduction also follows from the breeders' method of estimating the amount of blood of a given ancestor which an animal contains. Thus if the ancestor is a sire the offspring are considered as 50 per cent of the sire's blood; if it is a grandparent the offspring are considered 25 per cent; if it is a great-grandparent 12½ per cent: if it is a great-great-grandparent 6¼ per cent. It does not take long for one to see that the influence of any ancestor must be proportional to the number of generations they are away from the animal pedigreed. As the ancestors of note in any pedigree are generally at least great-grandparents and often even further removed it is at once clear that famous ancestors should in general have little effect in predicting the relative productivity of an animal pedigreed. Thus the conclusion derived from the study of the actual results agrees with common sense results as showing that famous ancestors are on the whole a poor means of predicting the productive worth of an animal. Thus any hope which may be derived from the study of pedigrees as such is exhausted. It is necessary now to turn to the further elaboration of the pedigree known as the pedigree with performance records. For this purpose we take the pedigree as published in Holstein-Friesian Foundation (6) of the cow Molly Veeman Segis Pontiac No. 283159.

It will be noted that the pedigree of Molly Veeman Segis Pontiac contains all the information which is given for Baron Netherland DeKol plus the records of performance for the animals contained in the pedigree. From these data it is possible to obtain inbreeding, relationship coefficient and any famous ancestors which occur in the pedigree of this animal plus the information as to the performance in milk production and butter-fat percentage or the progeny performance for milk production and butter-fat percentage. The animal is a phenomenal cow, chosen particularly because her pedigree does fulfill most of the conditions of an excellent production pedigree. The animal herself has 7-day and 365-day records of a very high degree of merit. She contains much of the Pontiac blood being inbred to King of the Pontiacs, Pontiac Korndyke and Pontiac Artis. Study of this pedigree shows that most of the animals have excellent records themselves or that their progeny have records of merit.

MOLLY VEEMAN SEGIS PONTIAC
No. 288159

Completed record March 5, 1922.

Record made at 6y 5m 8d. 1278.99
Milk 28488.20
Average % fat 8.58
Butter 7 days 36.11
Milk 718.10
Record made at 5y 3m 18d. 32.48
Milk 608.60
Butter 30 days 110.27
Milk 2780.40
Butter 365 days 806.80
Milk 22979.90
Record made at 2y 4m 4d 28.61
Milk 502.00
Butter 30 days 107.47
Milk 1949.00

1 A.R.O. daughter.
1 A.R.S.O. daughter.
1 proven son.
King Homestead Pontiac Veeman
Another son Grand Champion, Michigan State Fair, 1923.

SIRE

KING SEGIS PONTIAC COUNT 93909
37 A.R.O. daughters.
5 above 35 lb.
9 others above 30 lb.
12 from 20 to 29.24 lb.
7 above 700 lb. milk.
20 A.R.S.O. daughters.
11 from 1000 to 1287 lb.
Sire of: (year records)
Princess Changeling Segis
........................1287.50
Milk 31063.30
Molly Veeman Segis Pontiac—
Butter 365 days 1273.99
Milk 28488.20
Beauty Beets Walker Segis—
Butter 365 days 5y ... 1230.34
Milk 30814.00
Butter 365 days 4½y.. 1021.03
Milk 27175.00
Butter 305 days 2½y.. 1040.04
Milk 25343.30
Silver Bow Pontiac Segis—
Butter 365 days 1212.98
Milk 30009.40
Jewel Pontiac Segis 3½y 1171.15
Milk 27068.50
(World's record when made)
Butter 305 days, 20m.. 1004.25
Milk 21891.80
Beauty Girl Pontiac Segis
3y 1112.91
Milk 24924.70

KING SEGIS PONTIAC 44444
194 A.R.O. daughters.
8 from 30 to 37.56 lb.
51 from 20 to 29 lb.
23 A.R.S.O. daughters.
2 over 1000 lb.
97 proven sons.
43 30-lb. granddaughters.
16 1000-lb. granddaughters.
Sire of:
K S P Lily McKinley—
Butter 365 days 4½y .. 1199.84
Milk 24569.40
K S P. Andire 1064.59
Milk 23510.40

K P LILITH CLOTHILDE 110228
Butter 365 days at 4y .. 1043.28
Milk 22229.80
(World's milk record when made)
Butter 7 days at 5y.... 29.04
Butter 30 days 120.65
Butter 7 days 4 y 27.50
Milk 600.00
Butter 30 days 113.89
Milk 2374.50
5 proven sons.
17 30-lb. granddaughters.
Full sister to:
K P Lilith Boon 32.22
K P Lilith Lady Clothilde 28.47

KING SEGIS 36168
87 A.R.O. daughters.
11 from 30 to 35.56 lb.
47 from 20 to 29.1 lb.
2 A.R.S.O. daughters.
87 proven sons.
18 1000-lb. granddaughters.

PONTIAC CLOTHILDE DEKOL 2d 69991
Butter 7 days at 6½y 37.21
Milk 046.10
Butter 365 days 1271.60
Milk 25318.00
(World's butter records when made)
4 A.R.O. daughters.

KING OF THE PONTIACS 39037
283 A.R.O. daughters.
37 from 30 to 44 lb.
161 from 20 to 29 lb.
51 A.R.S.O. daughters.
5 over 1000 lb.
231 proven sons.

LILITH CLOTHILDE BOON 78841
3 A.R.O. daughters—
K P Lilith Boon 32.22
K P Lilith Clothilde 5y .. 29.04
Butter 305 days 4y 1043.28
1 28-lb. 4-year-old.
2 other A.R.S.O. daughters.

[illegible] PIETERTJE'S P[illegible]
29130
90 A. R. O. daughters
3 from 30 to 38.36 lbs.
40 proven sons.

A. & G. INKA MCKINLEY 55168
Butter 7 days at 9½y. 29.02
Milk 661.10
4 A.R.O. dghtrs. from 20 to 28.89 lb.

PONTIAC KORNDYKE 25982
151 A.R.O. daughters.
18 from 30 to 42.1 lb.
4 1000-lb. daughters.

PONTIAC CLOTHILDE DEKOL 49057
Butter 7 days at 6 y...... 23.11
2 A.R.O. dghtrs. with 31 & 3. lb

PONTIAC KORNDYKE 25982
151 A.R.O. daughters.
18 from 30 to 42.1 lb.
4 1000-lb. daughters.

PONTIAC LUNDE HENGERVELD 51585
Butter 7 days at 5 y........ 28.41
Milk 559.80
1 A.R.O. daughter.

LILITH PAULINE DE KOL'S COUNT 78130
98 A.R.O. daughters.
4 from 30 to 33.6 lb.
1 1000-lb. daughter.

CLOTHILDE PIETERTJE BOON 61391
1 A. R. O. daughter ....
Zada D. K. Count. .24 m .. 12.29
Milk 247.10

DAM:

MOLLY VEEMAN ARTIS 2d 182421
Butter 7 days at 4½y .. 18.25
Milk 381.70
Butter 7 days at 3½y . 13.04
Milk 303.90
1 A.R.O. daughter—
Mollie Veeman Segis Pontiac
Butter 365 days 6y ... 1278.90
Milk 28488.20
Butter 7 days 36.11
Milk 718.10
Butter 7 days 5y 32.48
Milk 608.60
Butter 30 days 119.27
Milk 2789.40

KING PONTIAC ARTIS 63094
20 A.R.O. daughters.
2 with 31 and 38 lb.
11 from 20 to 27.85 lb.
5 A.R.S.O. daughters.
1 with 1018 lb.
17 proven sons.
Sire of:
Artis Pontiac Saskia ... 33.42
Milk 601.10
Butter 30 days 140.16
Milk 2700.10
Artis Pontiac Susie Judith
4½y. 31.02
Milk 632.30
Butter 365 days 1018.74

MOLLY VEEMAN ARTIS 143719
Butter 7 days at 20 m.. 12.79
Milk 223.80
2 A.R.O. daughters—
Molly Veeman Walker 3½y 21.26
Milk 403.50
Butter 7 days 4½y ... 20.21
Milk 452.30
Butter 7 days 30 m .. 13.40
Milk 317.50
Molly Veeman Artis 2d
4½y 18.25
Milk 381.70

KING OF THE PONTIACS 39037
283 A.R.O. daughters.
37 from 30 to 44 lb.
161 from 20 to 29 lb.
51 A.R.S.O. daughters.
5 over 1000 lb.
231 proven sons.

PONTIAC ARTIS 01114
Butter 7 days at 6½y .. 31.71
Butter 30 days 120.44
Milk 2488.50
Butter 365 days 1076.91
Milk 21834.78
3 proven sons.

SIR KORNDYKE PONTIAC ARTIS 46301
66 A.R.O. daughters—
Ruth Pontia Veeman Korndyke 34.16
7 others over 30 lb.
32 from 20 to 29.70 lb.
0 A.R.S.O. daughters.
56 proven sons

PLEASANT HILL MOLLY VEEMAN 100920
Butter 7 days at 8y 25.88
Milk 551.80
Butter 30 days 100.15
4 A.R.O. daughters
1 22-lb. 4-year-old
1 proven son.

PONTIAC KORNDYKE 25982
151 A.R.O., daughters.
18 from 30 to 42.1 lb.
4 1066-lb. daughters.

PONTIAC LUNDE HENGERVELD 51585
Butter 7 days at 5 y...... 28.41
Milk 559.80
1 A.R.O. daughter.

HENGERVELD DE KOL 23102
116 A.R.O. daughters.
10 from 30 to 33 6 lb.
67 proven sons.

PONTIAC CLOTHILDE INKA 44452
Butter 7 days at 9 y........ 20.36
Milk 392.80
4 A. R. O. daughters.

SIR KORNDYKE MANOR DEKOL 28133
51 A.R.O. daughters.
4 from 30 to 35 lb.
19 from 20. to 28.7 lb.

PONTIAC ARTIS 01114
Butter 7 days at 6½y. .. 31.71
Butter 365 days 1076.91
Milk 21834.70

SIR VEEMAN HENGERVELD 36158
139 A.R.O. daughters.
21 from 30 to 37 lb.
10 A.R.S.O. daughters.

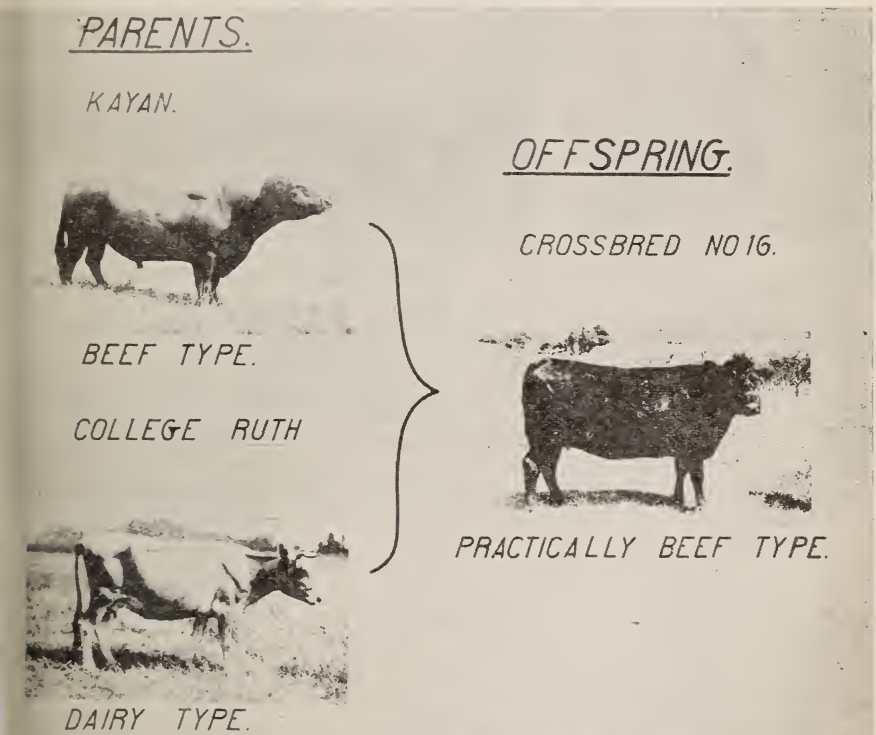
ZELLA BERYL 73128
Butter 7 days at 4½y 17.48
Milk 483.50
3 A.R.O. daughters.

The question may be asked as to what is shown by such performance records? Do we know anything more about what a given individual is likely to produce or what her offspring are likely to produce, if we know the Advanced Registry performance records in the pedigrees of such animals? In other words have we any information which will enable us to interpret such performance records in terms of heredity so that we will be able to predict with any degree of certainty what the performance of an animal so pedigreed will be when it comes to milk production or to official Advanced Registry testing? This question is one on which the Maine Agricultural Experiment Station has been working for the last ten years. Attention may now be turned to the evidence thus accumulated in trying to lay a foundation on which to interpret the worth of a pedigree in terms of future milk production.

In attempting to answer this problem the first question, which might be asked, is whether or not an animal with a pedigree is better than the grade whose parents are condemned to oblivion due to the lack of any registry system for such animals. The answer to this question was indicated many years ago by the work of such men as Van Norman, Eckles, and others in this country as well as by much similar information collected especially in Denmark in connection with Cow Test Associations. The problem has, however, been brought particularly to the fore in the last nine years, by the interesting experiments reported by Kildee and McCandlish (7), by Olsen and Biggar (8), by Lawritson, Hendrickson and Nevens (9), and Hayden (10). These experiments point to the conclusion that in the breeding of purebred dairy bulls to unpedigreed cows there results an increase in milk yield and butter-fat in the offspring. This increase in milk yield is more pronounced for the purebred Holstein-Friesian bull and is in general accompanied by a decrease in the butter-fat percentage of offspring of such bulls. The increase in milk yield is generally not so great for the Jersey and Guernsey crosses but the fat per cent is frequently increased so that the net fat return is increased. These facts indicate a very pronounced possible increase in the milk yield and butter-fat production of unpedigreed cows by the use of purebred bulls.

It is of interest to consider somewhat critically the reasons for these results. The work initiated by Pearl (11) (the writer is responsible for the analysis of the results) and by Cole (12) in obtaining definite controlled crosses of certain levels of milk production and butter-fat percentage, together with the work done in Denmark and analyzed by Ellinger, (13) the crosses made by Bowker and analyzed by Castle (14) and Gaines (15) all point to the conclusion that progeny of parents, one of which is relatively pure for high milk yield and the other of which is relatively pure for low milk yield, have milk yields intermediate between the two parents, approaching more nearly the higher producing parent. But in crosses of high and low butter-fat percentage animals the butter-fat percentage of the resulting progeny are intermediate between the two extremes tending to approach the butter-fat percentage of the lower parent. Purebred animals have started their existence as purebreds in relatively small communities and have been developed as purebreds separate from the other breeds. In other words there has tended to be a concentration of inheritance in our pure breeds of cattle or, as we may say, a concentration of prepotency for certain things has resulted in the different breeds. To take the extreme case most easily recognized by the eye, there has been such a concentration of prepotency of the beef characters in such beef breeds as the Shorthorn, Hereford, and Aberdeen-Angus, that when these animals are crossed on poorly fleshed scrub cattle there results a first generation animal carrying many of these purebreds' beef qualities. Furthermore should the cross happen to have been to a Hereford, the prepotent white face of the Hereford will also appear in the offspring.

The breeders of beef cattle have been much quicker to recognize this prepotency of the purebreds than have the breeders of dairy cattle. Thus, if we examine the census figures we find that of the bulls in service there are 53.4 per cent, which are purebred, against 25.4 per cent of such purebred bulls in service on dairy cattle. The percentage of purebred females while not so large, shows again that the breeders of beef cattle are more alive to the prepotency of purebred animals than are the breeders of dairy cattle. Thus, 4.1 per cent of the females in the beef breeds are purebred stock whereas only 3 per cent of the females in dairy stock are purebred. This difference in breeders of beef cattle versus those breeding dairy cattle is, in the writer's opinion, due to the fact that a beef man can easily see the effect of using a purebred bull on cattle used for beef purposes, whereas the effect is not so evident to the dairy cattle breeder unless he sits down and figures up his milk returns. The points for the beef animals may be illustrated by the accompanying photograph of one of the animals in the station experimental herd, Crossbred No. 16. The parents of this animal were the purebred Aberdeen-Angus sire, Kayan, and the Jersey cow, College Ruth. The beef characteristics of Crossbred No. 16 are easily noted from the photograph.



Photographs showing the prepotency of the beef characteristics in crosses of purebred beef animals. This photograph illustrates the progeny of the Aberdeen-Angus sire, Kayan, when mated to the Jersey cow, College Ruth. Block for plate courtesy "Scientific Agriculture."

The effect of using purebred Jersey sires on the ordinary mixed unpedigreed stock results in increases in milk yield which are entirely comparable with those increases in beef characteristics. These increases in milk yield often amount to as much as 100 per cent of the milk yield of the original dam. The desirability of using bulls whose pedigrees are known and which have been bred for dairy purposes for a considerable period of time is evident to anyone who cares to investigate the figures on the subject.

There is then a concentration of prepotency in pure breeds as compared with the mixed condition found in unregistered stock. This concentration of prepotency leads to certain results on breeding these pure breeds to mixed stock exemplified by the increase in milk yield and butter-fat production of these first generation animals. These considerations show that the mere fact of an animal's holding registration papers is an indication of probable greater worth for this animal as a breeder as compared with an unrecorded animal, because it shows that a definite effort has been made in its breeding to develop certain lines of production and thus concentrate on certain prepotent effects.

The question of how the inheritance of milk yield and butter-fat percentage takes place in registered animals may now be asked with the idea of utilizing these facts in making some prediction of what the milk yield or butter-fat percentage of an animal of unknown production would be when tested on the basis of the known milk yield and butter-fat percentage of her parents or ancestors further removed. These facts are taken from an extensive study of inheritance as conducted by the Biological Laboratories of this Station. The first problem to be taken up is the problem of the relation of milk yield and butter-fat percentage of full sisters.

MILK YIELD AND BUTTER-FAT PERCENTAGES OF FULL SISTERS.

Such a comparison gives a measure of the effect of the sire and dam on the milk yield of the progeny. When contrasted with the relation of the milk yield and butter-fat percentages of half sisters, it gives us a measure of the influence of both sire and dam on the production of the progeny. The results from the comparisons of the milk yields of full sisters, half sisters with a common sire, or half sisters with a common dam are shown in figure 9.

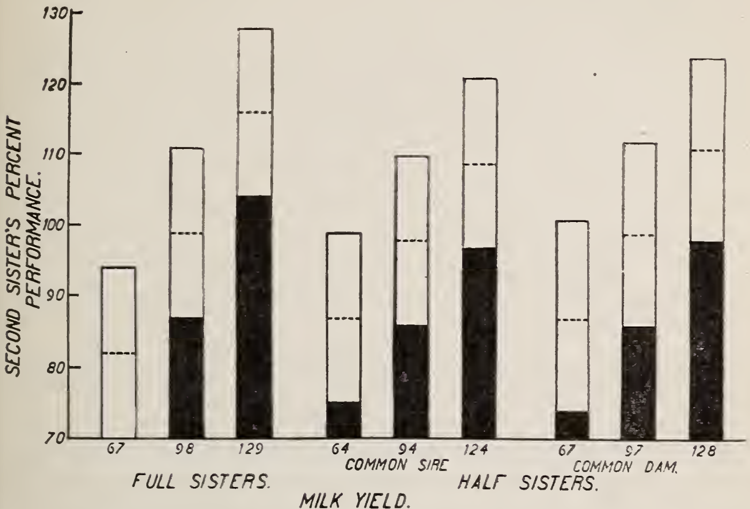


FIG. 9. Relation between the milk yields of full sisters, of half sisters with a common sire, and of half sisters with a common dam. The dotted line shows the average production, the white enclosed space shows the limits necessary to include 50 out of every 100 second sisters for a given grade of milk production of the first sisters.

This figure pictures the results as percentages of the average production of the breed. One hundred per cent represents the average production of milk over a 365-day period for the cow aged 8 years and 3 months. This average production for full sisters is 19438 pounds of milk. This production of milk in a 365-day period may seem a good deal to many dairymen who have not done Advanced Registry testing. It should be remembered, however, that the work of Eckles (17) has shown that Advanced Registry records are 1⅔ times in their production than are the records of the same cows made under average good conditions. In view of this fact the dairyman is justified in dividing the Advanced Registry record by 1⅔ in comparing it with that made in his own herd under average good conditions. In the study of pedigrees and in the purchase of dairy stock these facts should be kept in mind in evaluating the worth of any animal which is so pedigreed. For comparative results, however, such records when all made in the Advanced Registry are comparable and furnish fairly satisfactory data for inheritance work.

The full sister which produces 100 per cent may be considered as producing the equivalent of the average cow or 19,438 pounds of milk in mature form, 8 years, 3 months. Productions less than this figure are correspondingly less than the average in the percentage of milk they produce and productions more than that figure are correspondingly more than this percentage. The results may be concretely illustrated as follows. If a full sister gives 13,000 pounds of milk and the average milk production of full sisters for the breed is 19,438 pounds the cow giving 13,000 pounds of milk produces only $\frac{13000}{19438}$ or 67 per cent of the average. On the other hand a cow giving 25,000 pounds of milk produces 25,000 ÷ 19,438 or 129 per cent of the breed's average. The percentages of milk production are shown graphically for three groups, those cows giving 13,000 pounds of milk, 19,000 pounds of milk and 25,000 pounds of milk. The first full sister's percentage of milk yield is 67 per cent as shown in column 1. The average percentage of milk yielded by the second full sister is 82 per cent, for this group. This is shown as the dotted bar.

Besides the average production of full sisters we wish to know something more about them. Namely, how much variation will there be in the milk yields of second full sisters when we know the milk production of the first full sister? The information which it is desired to obtain may be illustrated as follows: Suppose 100 cows which have full sisters whose milk yields are 19,000 pounds or 98 per cent of the average. It is known from the above that the average milk yield of these 100 cows will be about 99 per cent of the average for the breed. The question on which information is desired is how much on either side of this average will these 100 cows vary in their milk production. For our purposes we have chosen to state the problem in this way: What limits of milk yield would include 50 out of the 100 cows whose production is nearest that of the average of 99 per cent? These limits would, of course, be on either side of the average production. It is possible to determine them by arranging the cows in order of their milk production and counting off the first 25 on either side of the average production. The milk productions of the 25th cow on either side mark off the limits which would include 50 out of the 100 cows; in other words, the range between which 50 per cent of the full sisters would be found in their milk yield. This method gives a measure of the variation which we may expect in the milk yield of any individual cow on predicting it from the milk yield of a full sister. Thus, where a first full sister's milk yield is 67 per cent, the average of the second full sister's milk yield is 82 per cent and the range of variation necessary to include 50 out of 100 such second full sisters would be 70 per cent to 94 per cent.

This is marked by the ends of the white area in the first column of figure 9. This figure shows that as the production of the first sister increases, the average production of the second sisters also increase. For the second column, where the first full sister gives 98 per cent, the average of the second full sisters is 99 per cent and the range necessary to include 50 out of every 100 second sisters is from 87 to 111 per cent. For those full sisters which have an average milk yield of 129 per cent the second full sisters have an average milk yield of 116 per cent. The range necessary to include 50 out of every 100 of the second full sisters is from 104 to 128 per cent.

The construction of the columns showing the milk yields of the half sisters from common sire and from common dam is the same as that of the full sisters. The average percentage of milk yield is given as the dotted bar across the white space and the ends of the white space represent the limits necessary to include 50 out of every 100 of the second half sisters.

It is noticeable that full sisters tend to resemble each other in milk yield more closely than do half sisters, due of course to the greater common inheritance which they obtain from both sire and dam instead of just from one parent. Thus for those cows which have a common sire we note that where the first half sisters are 64 per cent in their milk yield the average of the second half sisters is 87 per cent, whereas for full sisters where the first sisters have 67 per cent, the second full sisters have an average of 82 per cent or the full sisters tend to resemble each other in their milk yield nearly 7 per cent more closely than do the half sisters. This same fact is brought out by the other extreme. Where the half sisters have a milk yield of 124 per cent the second half sisters have an average milk yield of 109 per cent, whereas for the full sisters, the first full sister's milk yields of 129 per cent have an average second full sister's milk yields of 116 per cent. The full sisters are consequently 3 per cent closer in their milk yield than the half sisters. The same general fact holds for the relation of the milk yield of half sisters with a common dam as compared with the milk yields of full sisters.

A point of considerable importance in pedigree study may now be made. If a sire has a first daughter which is rather poor in milk yield it is more than an even chance that by breeding this sire to this same cow another daughter will be obtained which also will have a relatively poor milk yield. If on the other hand a sire obtains a daughter above average in milk yield it is unwise to change this sire in the hope of getting another daughter from this same cow of greater milk yield than the first, since the chances are more than even of choosing a sire which will decrease rather than increase the milk yield of the resulting offspring.

While the comparison shown in figure 9 does not bring out the facts very clearly, it may be stated that the data on which the comparison is based when analyzed particularly for this point show that the relation between the milk yields of half sisters is only slightly more than half of that between full sisters. In other words, in attempting to estimate the probable production of an unknown animal by pedigree study if records on relatives are given we can place more confidence in a record of a full sister than we can in a record of a half sister to the animal in which we are interested.

It will be noted that the graphs show a close correspondence between the average milk yields of second half sisters irrespective of whether they have a common dam or a common sire. Such evidence points to the equal effect of the sire and dam on the milk yield of the daughter. This conclusion has been confirmed by an extended and rather complicated study of the interrelation of milk yields of different groups of animals.[2]

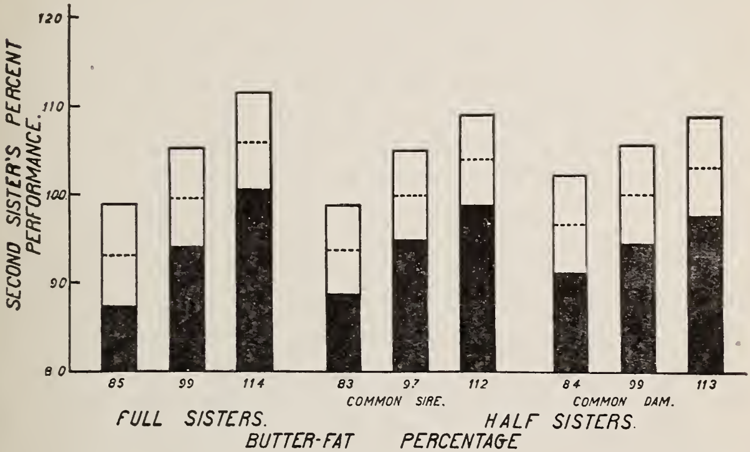


FIG. 10. Graphs showing the relation between the butter-fat percentages of full sisters, of half sisters with a common sire, and of half sisters with a common dam. The method of forming this graph is similar to that for the milk yields given in Figure 9. The dotted line represents the average butter-fat percentage of the second full sisters or half sisters, as the case may be, whose first sisters have a given butter-fat percentage. Thus in the case of those full sisters that have a butter-fat percentage of 85 per cent, the second full sisters have an average butter-fat percentage shown by the dotted line of 93 per cent. The limits of the white area on either side of the dotted line mark off the percentages necessary to include 50 out of every 100 such second full sisters. In other words, it gives a measure of the accuracy of prediction for any given individual's record based on the record of its full sister, or half sister, as the case may be. It will be noted from this chart that the butter-fat percentage of second sisters increases as that of the first sisters increases. In other words, there is quite a marked relation between the butter-fat percentages of sisters. This relation is obviously greater for the full sisters than it is for the half sisters. This fact indicates that the greater common inheritance of full sisters, as derived from both sire and dam, has a more marked influence than does the inheritance derived from only one parent.

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[2]For those who are interested in following this subject further it is suggested that they consult the writer's book on Milk Secretion, Williams and Wilkins Co., Baltimore, as this book contains a much more complete treatment of this entire subject.

The same essential facts are shown for the relation of the butter-fat percentages of full sisters and of half sisters. This does not mean that milk yield and butter-fat percentage are inherited together, in fact all the evidence points to the conclusion that they are independent or nearly so in the Holstein-Friesian breed. This means only that while the inheritance for the two is brought about by separate parts in the machine, the quantitative inheritance is approximately the same both in the milk yield and the butter-fat percentage. Figure 10 shows the graphs for the butter-fat percentages of these groups of sisters.

In view of these facts we can draw certain conclusions with regard to the value in pedigree study of the records for milk yields or butter-fat percentages on full sisters or on half sisters. The record of a cow predicts the probable milk yield of her full sister much more accurately than it does that of a half sister whether the half sister be by the same sire or from the same dam. Thus in purchasing a bull (which has daughters of excellent performance) and bringing him into a herd the daughters which this bull would get would not be expected to have the same excellence as those in the herd from which he came because of the fact that this bull is going to be used on entirely different cows, perhaps inferior to those to which he had been previously bred. The offspring which he gets will furthermore be only half sisters of those of the herd from which he came, whereas if he were continued to be used in the original herd it is probable that he would get many full sisters and thus maintain more nearly the high level of performance previously established. The same conclusion is to be drawn for the cows which are purchased on the basis of the production of their daughters, for unless they are bred to higher class bulls than those to which they were originally bred it is more than an even chance that their daughters will not do so well as if the previous sire had been used.

Milk Yields of Mother and Daughter.

The study of the milk yields of mother and daughter furnish what is frequently the most direct comparison available to the breeder. The daughters' milk yields are slightly in excess of those of their dams. The average milk yield of the daughters is 19,600 while that of their dams is 18,800 pounds for the maximum production at 8 years and 3 months. The writer has studied the records of 216 daughters which come from dams whose milk yield is over 20,000 pounds. These daughters' average production is 21,778 pounds for the 365-day period. The 395 daughters that come from dams with milk yields less than 20,000 pounds have an average production of 18,393 pounds. In other words, the daughters from cows with productions greater than 20,000 pounds have an average milk yield 3,385 pounds greater than the daughters which came from dams whose milk yields are less than 20,000 pounds.

When the yield of the dam is low, the milk yields of the daughters tend to be higher. They approach the average of the breed. On the other hand when the milk yield of the dam is large, the milk yield of the daughter is also large, although not quite so large. Figure 11 shows on a percentage basis the relation of the milk yield of the daughter and dam.

This figure shows that when the dams' milk yield is 69 per cent of the average of the breed the daughters' milk yield is 85 per cent. If the dams' milk yield is 101 per cent, the average daughters' milk yield is found to be 100 per cent. If the dams' milk yield is 133 per cent, the daughters' milk yield is found to be 116 per cent. For an increase in percentage of milk yield of 64 per cent for the dam there has been a resulting increase of milk yield in the daughters of 31 per cent. This increase shows the importance of having in pedigrees dams with records which are relatively high. The record of the dam is one of the best pieces of evidence on which to base any estimate of the probable production of the daughter. In fact this close relationship between the milk yield of daughter and dam makes it an open question if for the small breeder it is not better to purchase daughters from relatively high producing dams than it is to pay too much attention to and too much money for a supposedly high producing bull. The reason for this lies in the fact that a daughter's production may be predicted much more accurately from the record of her dam than can the record of a sire's offspring from the records of any of the sire's ancestors. This point will be discussed further in the comparison of the records of grandparents with those of their granddaughters.

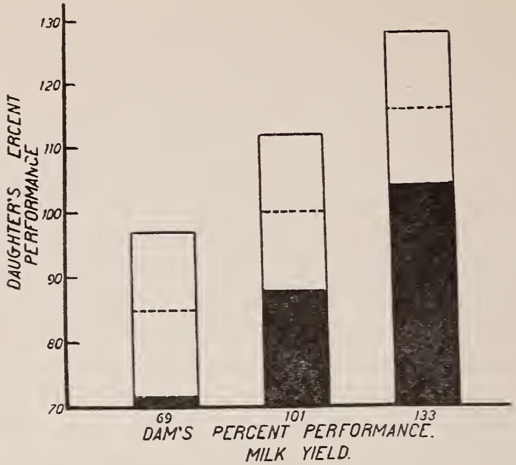

FIG. 11. Graph showing the relation between the milk yields of dams and daughters in the Holstein-Friesian Advanced Registry. The productions are given as percentages of the average production for the breed. The construction of the figure is as follows: The dotted line indicates the average milk yield of the daughters coming from dams of a given milk yield. The ends with the white area represent the variation in milk yield necessary to include 50 out of every 100 daughters when they come from dams of a given milk yield. That is, daughters from dams producing 69 per cent have an average production of 85 per cent and 50 out of every 100 of these daughters would have milk yields between 72 per cent and 97 per cent of the breed's average. From these graphs it will be noted that the increase of the dam's milk yield results in an average increase of the daughters' milk yield of somewhat less an amount. Thus for dams with an average milk yield of 69 per cent the daughters' average milk yield is 85 per cent, whereas for dams with milk yield of 133 per cent the daughters' average milk yield is 116 per cent. Or for an increase in the percentage of milk yield of dams of 64 per cent there is an average increase in daughters' milk yield of 31 per cent.

Another question on which information is needed is how much on either side of this average will these 100 cows vary in their milk production. For our purposes the problem may be stated in the following way. What limits of milk yield would include 50 out of 100 cows whose production is nearest the average of 100 per cent. These limits would of course be on either side of the average production. It is possible to determine them by arranging the 100 cows in the order of their milk production and counting off the first 25 on either side of the average production. The milk production of the twenty-fifth cow on either side would be the limits which would include 50 out of every 100 of such daughters. In other words, the twenty-fifth cow would mark the range between which 50 per cent of the daughters would be found in their milk yield. This method gives a measure of the variation which we may expect in the milk yield of any individual cow on predicting it from the milk yield of her dam. Thus where the dam's milk yield is 69 per cent the average milk yield of the daughters is 85 per cent and the range of variation necessary to include 50 out of every 100 such daughters would be from 72 per cent to 97 per cent. These limits are marked off by the ends of the white area of the first column of figure 11. In a similar manner the other columns represent the average production and range in production of daughters coming from dams of other grades of production.

Figure 11 shows that as the production of the dam increases the average production of the daughters increases also. Were it possible to picture it, the relation of sire and daughter would appear the same as figure 11 for the relation between dam and daughter, as it can be shown that the correlation between the potential milk yield of sire and the milk yield of the daughter are essentially of the same value as the correlation between dam and daughter where actual milk yields are available on which to determine the correlations. These data and the data on the average milk production of daughters with given grades of dams furnish a fairly accurate means of predicting milk yield when given pedigree records showing the milk production of the dam. The same is also true for the butter-fat percentage for although milk yield and butter-fat percentage are inherited independently, the butter-fat percentage follows the same laws as that of milk yield. These data are given in figure 12.

Figure 12 shows that as the butter-fat percentage of the dam increases the average butter-fat percentages of the daughters from these dams also increases. The variation of the daughters, while fairly large in amount, is still small enough so that the prediction of the daughter's butter-fat percentage from that of her dam is one of the preeminently important single considerations in pedigree study.

The next important point is the relation between the milk yields of grandparents and the milk yields of their granddaughters.

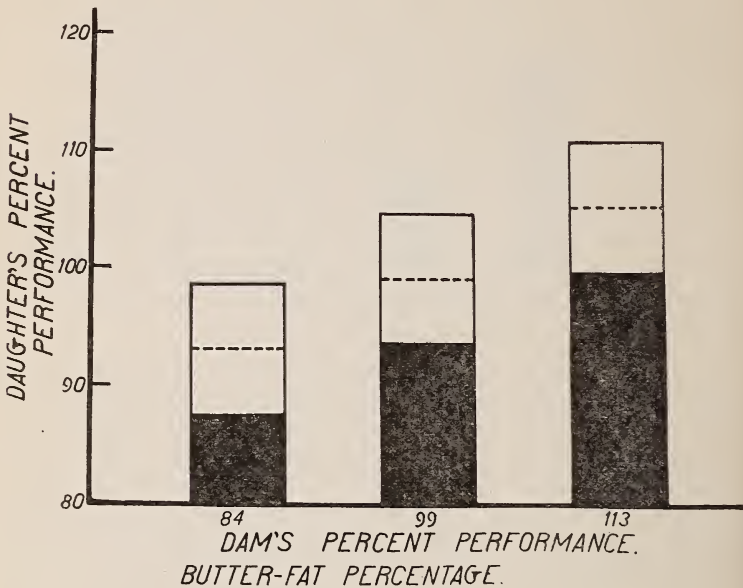

FIG. 12. Graphs showing the relation between the butter-fat percentage of daughter and dam as obtained from Holstein-Friesian Advanced Registry data. The construction of this figure is similar to that of figures 9 and 10, the dotted line indicating the average butter-fat percentage of the daughters and the ends of the white areas the variation necessary to include 50 out of every 100 daughters when they come from dams of a given butter-fat percentage. From this graph it will be noted that the increase in the dam's butter-fat percentages results in an average increase of the daughter's butter-fat percentages of somewhat lesser amounts. Thus for dams with a butter-fat percentage of 84 per cent of that of the breed's average, the daughter's average butter-fat percentage was 93 per cent of the breed's average. On the other hand, for dams which had an average butter-fat percentage of 113 per cent the daughters had an average butter-fat percentage of 105 per cent, or, for an increase of 29 per cent in the dam's butter-fat percentage there was a corresponding increase of 12 per cent in the daughter's butter-fat percentage. These facts show the importance of having dams with a relatively high butter-fat percentage in the pedigree when one of the objects of breeding is to raise the butter-fat percentage of the herd.

RELATION OF THE MILK YIELDS AND BUTTER-FAT PERCENTAGES OF GRANDPARENTS AND GRANDDAUGHTERS.

From the point of view of general breeding and pedigree study the record on the paternal granddam is probably of most importance. It is on this record that bulls are frequently purchased, in fact it is the most important record in the pedigree when these bulls are so young that they have no daughters of their own. For this reason the records of this parent will be taken as illustrative of the effect of the grandparents on the milk yield and butter-fat percentages of their granddaughters.

Before taking up this point the results of a study of the relations of milk yields of the grandparents to the milk yields of their granddaughters heretofore obtained may be summarized briefly. The study of the data reveals no significant differences between the influence of the grandparents taken individually, whether it be on the sire's side or the dam's side of the pedigree, on the production of their offspring either in milk yield or butter-fat percentage. The grandparents have only half the relation to the milk yields and butter-fat percentages of their granddaughters that the parents have. In other words, the record on a grandparent is nowhere near so good a measure, by which to predict the probable milk yield or butter-fat percentage of their progeny a generation removed, as is the record on the dam of that progeny. From the records of the Holstein-Friesian breed we find the following comparison between the milk yields of granddaughters and paternal granddams. If the milk yield of the paternal granddam is low, say 10,000 pounds the milk yield of the daughter will also be low, 17,297 pounds, when considered in comparison with the rest of the daughters. If the milk yield of the granddam is large, 30,000 pounds, the milk yield of the granddaughters has a large average, 22,373 pounds, when compared with the rest of the granddaughters. This increase is not anywhere near so pronounced as that for the relation of daughters' and dams' milk yields. In other words, the point brought out by this comparison is that the grandparents have an effect on the milk yields of their progeny, even though they are a generation removed but that this effect is not so great as the effect of the immediate parent. Thus in all pedigree studies the weight to be placed on a record occurring in the second generation is a good deal less than when the record occurs in the first generation. Furthermore the variation of the granddaughters with paternal granddams of a given production is much greater than the variation found for daughters of given grades of dams. Thus for paternal granddams of 14,000 pounds, a variation in the milk yield of 15,426-21,198 pounds is necessary to include 50 out of every 100 granddaughters. A prediction of the milk production of a granddaughter from the grandparent's record cannot be made so accurately as that of a daughter from the dam's milk yield. This conclusion is also true for the butter-fat percentages.

It is unnecessary to take the reader over the evidence for the third generation for this evidence is quite scattering due to lack of numbers. General conclusions from such an analysis can be stated very simply. The third generation individuals are found to influence the milk yields and butter-fat percentages of their progeny two generations removed to but a very slight extent, much less than do the grandparents. The examination of the records of the pedigree in their effect on the performance of the animal pedigreed has been carried to a limit so far as any practical conclusions can be drawn from such records.

There is one other phase of the pedigree which should probably be examined because of the frequency of its occurrence in pedigree study. In an examination of the methods of recording the performance of the sire it is frequently noted that this sire has a brother which in turn has daughters of very excellent performance. The conclusion is left to the breeder looking at this pedigree that these brothers' daughters will probably indicate what the unknown sire's daughters will do in their milk yield and butter-fat percentage. A little consideration shows that such a sire's daughters are first cousins to those of this brother. The comparison is therefore that of the milk yields and butter-fat percentages of first cousins to determine how good an indication such records really are and how good a basis they actually may be for forming judgment as to the probable productive worth of an animal. Stating the conclusions broadly it is found that these cousins are only about half as good indicators of the probable milk yield and butter-fat percentage of the animal pedigreed as are records on any of the grandparents.

The records of cousins are much less effective, therefore, than records of the parents.

This brief review of the main conclusions from the study of inheritance of milk yield and butter-fat percentage in relation to the reading of a pedigree brings out one further point, namely, the best combinations of ancestors or of relatives to predict the probable productive worth of an animal. Here again without going into the evidence the combination which has been found to be of the most value are records on a full sister and on the dam for predicting the probable milk yield or butter-fat percentage of a given animal. The next most important records are the records of a half sister by the same sire and a record on the dam for predicting the milk yield or butter-fat percentage of an unknown animal. Thus it is records immediately next to the animal pedigreed which are most important in pedigree study. We can in a sense discard as useless, unless they are very numerous, the records of the third and fourth generation individuals. They can, in the writer's opinion, be discarded even though they are very numerous because with these famous animals in any number in the third and fourth generation there is something wrong with any pedigree that does not show records in the first and second generation on the animals which come from these famous ancestors. A man cannot afford to leave the progeny of such animals unrecorded as to performance and therefore we have a right to expect performance records in such a pedigree.

WHAT ARE THE ESSENTIALS IN PEDIGREE WRITING AND READING?

The results of this brief summary of the long, tedious, painstaking work on inheritance in relation to pedigree writing and reading may be concluded as follows. First there appears to be little or no influence of inbreeding, of relationship, or of famous ancestors on the production of the progeny of dairy sires. It will be noted that the evidence shows that the inbreeding and relationship which occurs in the ordinary pedigrees as found in purebred breeds is relatively small in amount. The evidence from extensive experiments (on small animals particularly) shows that very intensive inbreeding such as mating brother and sister for a number of generations will generally result in the concentration of the prepotency of this animal but also in a decline in vigor in such inbred animals and a probable reduction in fertility. These last results may, however, be avoided by very careful selections.

It is indicated further that it is desirable to have animals which are registered because these registration papers show that a definite effort has been made to breed these animals to certain types of production and because this definite effort tends to make these animals pure for these types of production transmitting them as increased milk yields and butter-fat percentages to their offspring more frequently than an animal of unknown breeding with a probable mixed ancestry.

It is further shown that the parents and grandparents, sisters and half sisters, and to some extent cousins are the important relatives on which to base an estimate of the productive worth of an animal. As a pedigree goes beyond three or four generations the ancestors in it get so far removed from the animal pedigreed that the effect of any worthy ancestor even though pure for high production is diluted so much by the other ancestors in coming down through the generations that its effect on the animal pedigreed is so slight as to be of little or no value as a prediction of the progeny's probable production.

It is further shown that the animals on which greatest dependence may be placed in reading a pedigree are the recorded performances of the dam, full sisters, and half sisters. Next to these come the recorded performances of the grandparents.

These results of a strict and critical study of inheritance in dairy cattle are apparently confirmed by the opinion held by dairy cattle breeders in Denmark. Mr. Anthony (16) in showing the way in which sales catalogs are put up by Danish Breeders indicates that they give the records on three generations of the pedigree for the female ancestors. These are given as the age of the cow, her milk yield and butter-fat percentage and the number of pounds of butter produced. The pedigree is further completed by giving the prize winnings of the male ancestors for two generations. Judges then give the animal in question a rating as to its type, a rating as to the production of the ancestors and as to the external appearance of the ancestry.

To this record the writer would add the records of the progeny as the author's studies have shown these records important in indicating the progeny performance of any pedigreed animal. A pedigree of this type is the unvarnished record worthy of a careful consideration of any breeder either reading or writing pedigrees.

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LIST OF RECENT BULLETINS

No. 305. The Relation of Tree Type to Productivity in the Apple.
No. 306. Studies in Milk Secretion. XVII. Relation between Milk Yields and Butter-Fat Percentages of the 7-day and 365-day Tests of Holstein-Friesian Advanced Registry Cattle.
No. 307. Sterility Relationships in Maine Apple Varieties.
No. 308. The Blueberry Maggot in Washington County.
No. 310. The Cause and Permanence of Size Differences in Apple Trees.
No. 311. The Effect of Age on the Milk Yields and Butter-Fat Percentages of Guernsey Advanced Registry Cattle.
No. 312. Potato Spindle-Tuber.
No. 313. The Summer Food Plants of the Green Apple Aphid.
No. 314. Studies on Conformation in Relation to Milk Producing Capacity in Cattle. III. Conformation and Milk Yield in the Light of the Personal Equation of the Dairy Cattle Judge.
No. 315. Abstracts of Papers not Included in Bulletins, Finances, Meteorology, Index.
No. 316. The Importance and Natural Spread of Potato Degeneration Diseases.
No. 317. The Buckthorn Aphid.
No. 318. Interpretation of Dairy Pedigrees.
No. 319. The Blueberry Leaf-beetle and Some of Its Relatives.

The following bulletins are published in limited editions and are mailed regularly to libraries and to other institutions in exchange. They represent types of publications which are not sent to general mailing lists in the State but will be forwarded to any address on request, as long as the supply lasts.

Bulletin 317.

THE BUCKTHORN APHID. This bulletin contains an account of a small greenish aphid that overwinters on the buckthorn *(Rhamnus)* in the egg stage. The first spring generation develops on the buckthorn leaves, distorting them. Later winged generations disperse to seventy or more different species of plants which the aphids infest during the summer. The bulletin gives the life history of the aphid; a list of all its known food-plants, many of which are of economic importance; a record of the habits of the species which is a pest in vegetable and flower gardens; a report of its role as a carrier of plant disease; and suggestions for control.

Bulletin 319.

THE BLUEBERRY LEAF-BEETLE AND SOME OF ITS RELATIVES. Bulletin 319 contains an account of fifteen New England leaf-beetles belonging to the genus *Galerucella*. Five of these being previously unnamed, are described as new species. Among this number is a dull yellow or reddish brown beetle which is indicated as the blueberry leaf-beetle as both the adult beetles and their larvae feed upon blueberry leaves. The females deposit eggs from late May to late July so that a succession of the larvae are present for about eight weeks. The bulletin gives a description of the egg, larva and adult insect with drawings and photographs; an account of its distribution, foodplants, hibernation and other habits, natural enemies, and suggestions as to its control. Similar though briefer descriptive accounts are given of the other species and a key makes possible an identification of the different species.